The Role of Modeling Given Uncertainty

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Sources of Uncertainty in Biofuel LCA

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Types of Uncertainty

- Uncertainty is inherent within modeling for both direct and indirect LCA
    - **Aleatory Uncertainty**—Inherent randomness of a system
    - **Epistemic Uncertainty**—Data and knowledge gaps
- LCA guidance (ISO 14040) recommends sensitivity analysis to evaluate the robustness of the results

Uncertainty in Direct LCA

- Most LCA relies on a mix of collected LCI data *and* assumptions + modeled data
- Subject to year-to-year & regional variation
- Data gaps may require assumptions for parameters

Crop Production

- Fertilizer application
- Yield
- N_2O Emissions
- Chemical application
- Fossil fuel input
- SOC Change

Logistics

- Distribution distance
- Distribution mode

Fuel Production

- Yield
- Co-product displacement
- Fossil fuel input

Fuel Distribution

- Distribution distance
- Distribution mode

Adapted from Liska, 2015

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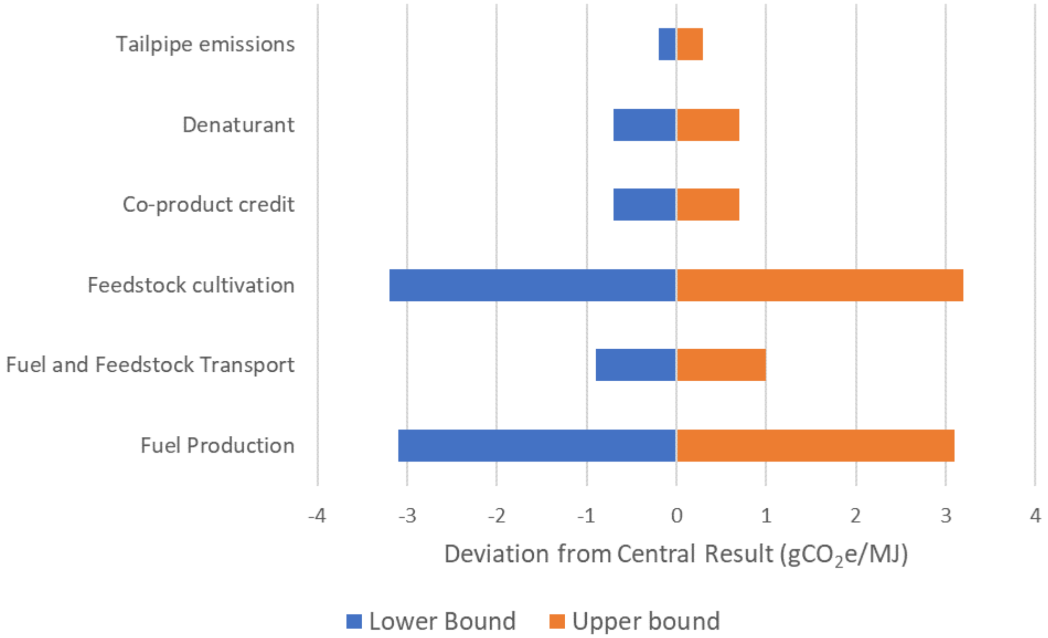
Uncertainty in Direct LCA

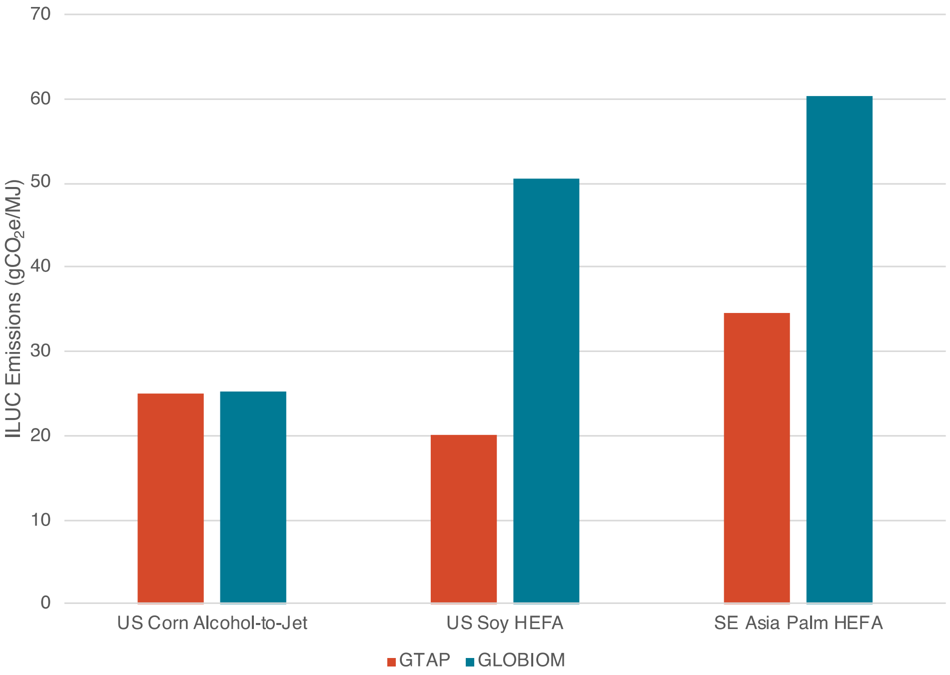
- Sensitivity analysis identifies which parameters & assumptions have largest impact on results
- Identify impacts of decisions on allocation
- Can be used to inform further research & data collection
- Can inform the likely range of outcomes



Adapted from Scully et al., 2021

Uncertainty in ILUC

- Greater reliance on modeling and assumptions than direct LCA
- Extremely sensitive to parameters & assumptions (i.e., decision uncertainty)
- Impacted by model choice, scenario design, analytical scope



Adapted from ICAO CORSIA LCA Methodology, 2019

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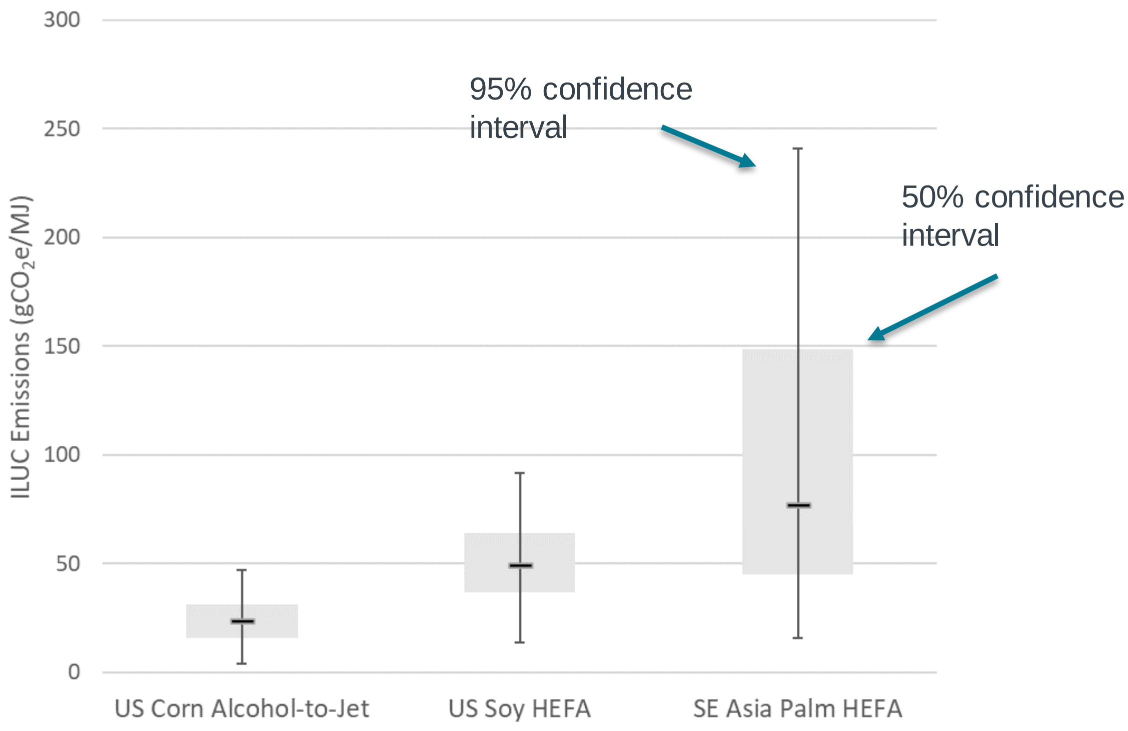

GLOBIOM ILUC Sensitivity Analysis; Adapted from ICAO CORSIA LCA Methodology, 2019

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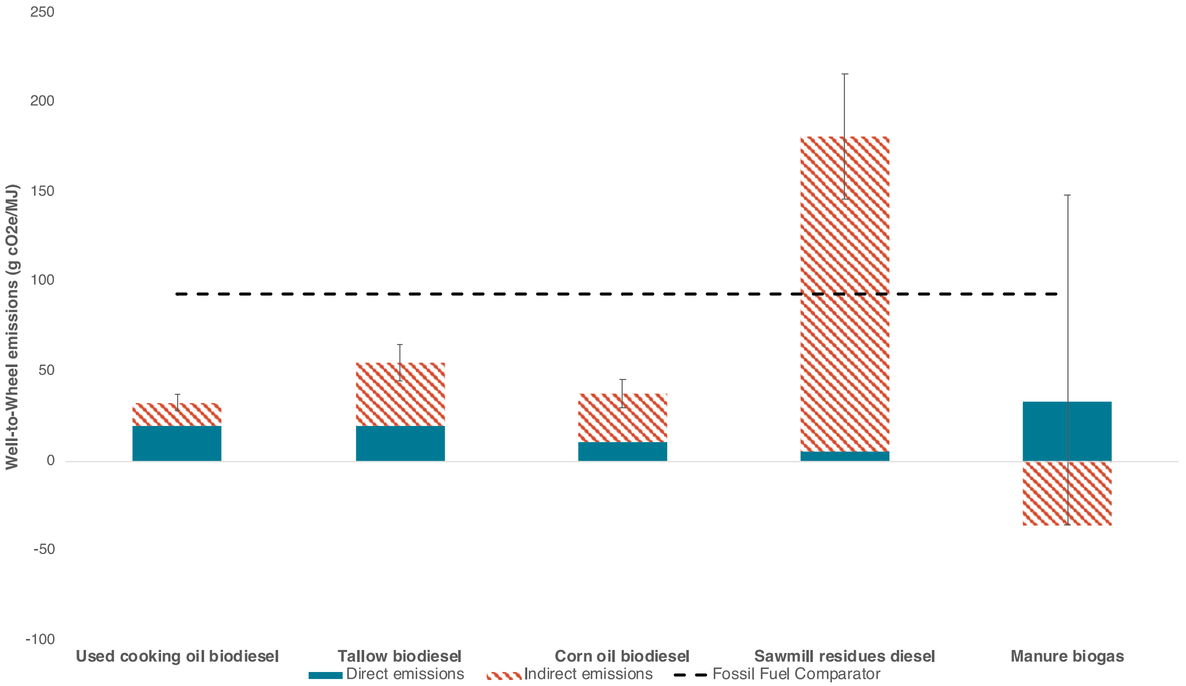
Beyond Existing Models

- Effects outside scope of many existing models
- Displacement & substitution effects
- Rebound effects
- These effects are often tied to behavioral assumptions (e.g., demand response)



Adapted from O'Malley et al., 2021

Making Sense of Uncertain Results

- Decide what range of outcomes is acceptable for policy (i.e., an uncertainty standard)
- Evaluate the range of results for a given pathway
    - Assess sensitivity analyses; identify key sources of parametric uncertainty & data needs
    - Where possible, compare trends across different models (e.g., ICAO CORSIA process)
    - Assess the risk of indirect effects outside of existing models

Using Modeling Results to Inform Biofuel Policy

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LCFS-Style GHG Accounting

- Inherent assumption of precision; policy value associated with incremental GHG reductions
- Greater reliance on collected data; site-specific inputs
- Typically combines direct, site-specific LCA factors with a single ILUC emission factor

GHG Reduction thresholds

- Lower threshold implies greater certainty of modeling results
- Higher threshold may exclude some low-CI pathways, in exchange for greater certainty

Policy	GHG Reduction Threshold	Scope
ICAO CORSIA	10%	Direct + Indirect
US RFS2	20%-60% by category	Direct + Indirect
EU RED II	50-65% by facility date	Direct only

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Other Eligibility Requirements

- “High-ILUC” risk exclusions (EU RED II, proposed Canada Clean Fuel Standard)
- Regulatory impact assessment may be used to assess consequential effects and identify high-risk pathways
- Based on trends identified in modeling, not necessarily specific LCA values

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Concluding Remarks

- LCA models provide valuable information, but are not necessarily definitive
- Identifying trends and risk areas just as important to LCA as specific emissions estimates
- Policy design can incentivize biofuels with greater **certainty** of GHG reductions

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Questions?

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